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Forest Health Protection

Pacific Southwest Region

Date: August 1, 2001
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To: District Ranger, Truckee Ranger District, Tahoe National Forest

Subject: Crystal Fire Marking Guidelines For Fire Injured Trees
Administrative Study Monitoring Report (Report # NE01 – 8)

Summary of Conclusions

Accurately predicting survivability of fire-injured trees is essential when planning rehabilitation and salvage activities in burned areas particularly if the intent is to leave trees that are likely to survive. Currently Wagener's "Guidelines for estimating survivability of fire-damaged trees in California" is one of only a few documents that are available to land managers. The Crystal Fire study has added to this limited amount of information with site-specific data. Based on this data and data obtained from other FHP studies we have determined that Wagener's survivability guidelines for percent live crown should be adjusted from 50% to 35% (Appendix B). Therefore, excluding cambium damage, trees with >35% remaining live crown would be expected to survive. It is also recommended that if the effort needed to sample cambium is impractical for salvage marking purposes than only percent crown scorch or percent live crown should be used to predict survivability of fire damaged ponderosa and Jeffrey pine in eastside forest types.

Background Information

The Crystal Fire began on August 4, 1994 and eventually burned approximately 7,300 acres on the Truckee Ranger District, Tahoe National Forest and the Carson Ranger District, Toiyabe National Forest (Figure 1). The area is located in the 22" to 26" isohyetal precipitation zone

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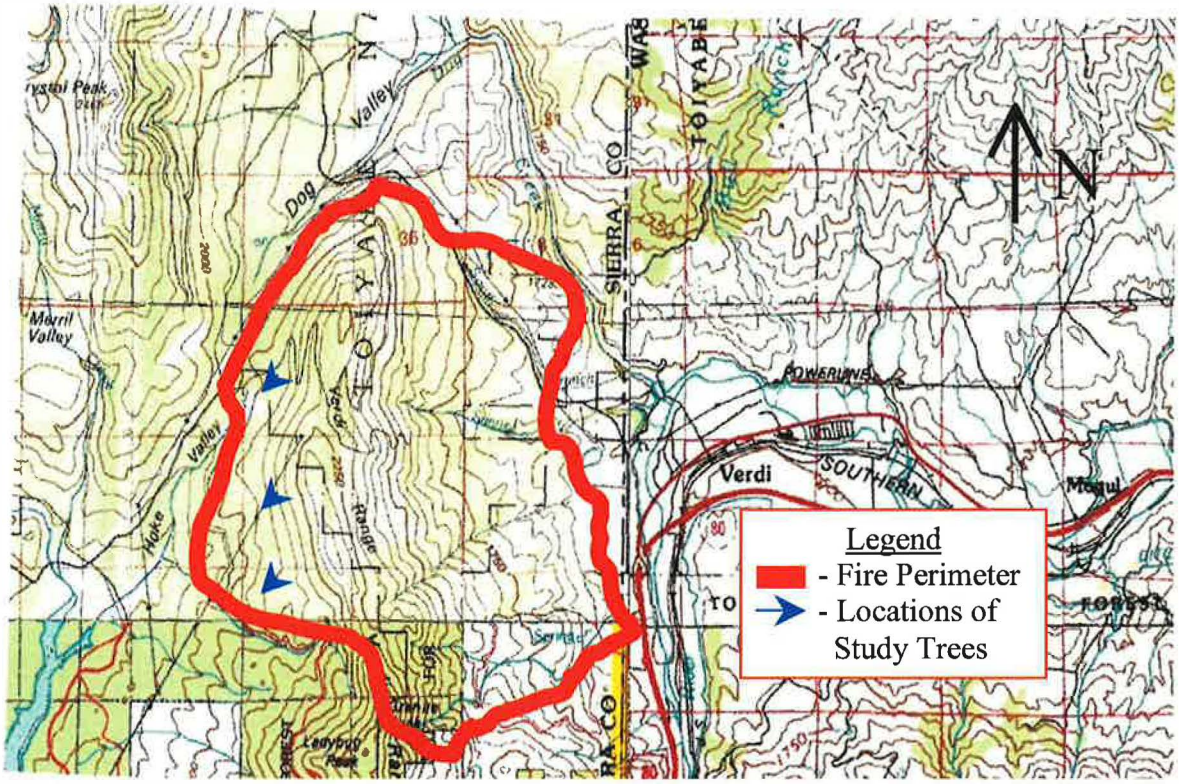
(considered to be a high risk for supporting true fir) at an elevation range between 5,000 to 7,500 feet. This area had experienced an extended period of below normal precipitation for the seven years leading up to the fire. High levels of white fir mortality, associated with the protracted drought period and fir engraver beetle attacks, were detected in this area throughout the early 1990's. As a result of this mortality the amount of standing dead fuel was extremely high. The burned area consisted of four forest types, red fir/red fir mixed conifer, white fir/Jeffrey pine/ponderosa pine, Jeffrey pine/ponderosa pine/bitterbrush and Jeffrey pine/ponderosa pine/mountain mahogany.

This study was implemented in June 1995 to evaluate the survivability of selected conifers that suffered different degrees of crown injury during the 1994 Crystal Fire. A total of 115 trees were selected, 55 ponderosa pine (*Pinus ponderosa*) and 60 Jeffrey pine (*Pinus jeffreyi*), representing a range of post-wildfire related crown injuries.

Fire intensity ranged from areas of complete vegetative consumption to areas of light under burning (Crystal Fire EA 1995). Rehabilitation efforts, focusing on preventing erosion and marking of salvage timber, began immediately following the fire.

Figure 1. Perimeter of Crystal Fire and location of study trees.



Salvage marking continued in Spring/Summer 1995 and included a re-evaluation of the previously marked stands to assess any change in tree condition over the winter. Tree survivability was determined by using guidelines adapted from Wagener (1961) (Appendix A).

Accurately evaluating fire damage and predicting survivability of trees is critical when planning rehabilitation and salvage operations. Tree survival from a given level of damage varies widely between species and sites. Localized fire effects relationships are essential tools for determining survivability yet few have been established. Documentation of fire effects on tree survival is necessary for providing the information required to establish these localized fire effects relationships (Ryan 1983). The Crystal Fire presented Forest Health Protection (FHP) personnel with an opportunity to monitor and evaluate the survivorship of individual Jeffrey pine and ponderosa pine, with various degrees of fire injury, on the eastside of the Sierra Nevada. It also allowed us to test the accuracy of Wagener's guidelines, the most widely used for estimating survival of fire-injured trees in California, when locally applied to an eastside forest type experiencing drought conditions. Information obtained from this study could then be used to support, enhance, or modify salvage marking guidelines and to assist in determining post fire bark beetle response for these conifer species under similar conditions.

Monitoring

The 115 ponderosa and Jeffrey pine trees were originally evaluated, documented, and photographed during June 1995. All selected trees had some degree of crown injury. Data collected included diameter breast height (DBH), height, and remaining live crown, recorded as a percentage of the original crown. It was determined at time of tree selection that remaining green crown was equal to remaining live crown. For the purpose of the guidelines the percent live crown is defined as the proportion of the original live crown that is still alive.

In addition, all signs and symptoms of bark beetle attacks, disease infections and mechanical injury were documented. All trees were monitored annually for five years to document any changes from their initial conditions. The ranges of characteristics and conditions of the trees, at the time of selection, are summarized in Table 1.

Table 1. Characteristics and Conditions of Study Trees

	Height Range (feet)	**DBH Range (inches)**	**% Live Crown Range**
Jeffrey pine (60)	43 – 108	15.2 – 31.3	18 - 100
Ponderosa pine (55)	32 – 83	13.7 – 33.3	14 - 100

Results

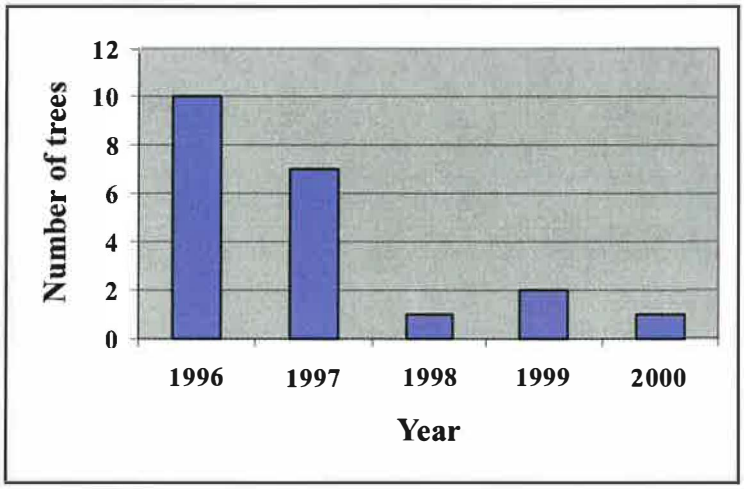
All reported results combine data taken for both Jeffrey and ponderosa pines as no difference in survival rate was found (JP = 80%, PP = 84%). As of August 10, 2000, 94 trees out of the original 115 remain alive resulting in an overall survival rate of 82 %. Based on Wagener's guidelines (greater than 50% live crown) the number of trees predicted to survive was 66/115 or 57%. Tree survival by percent of dead crown is presented in Table 2.

Table 2. Tree survival by dead crown percentiles.

Percent Crown Scorch	Total Number Of Trees	Number Alive as of Fall 2000	Percent Survival
0 – 10	17	17	100
11 – 20	3	3	100
21 – 30	10	9	90
31 – 40	17	14	82
41 – 50	19	19	100
Trees below would	be expected to die	based on Wagener's	guidelines.
51 – 60	21	17	81
61 – 70	10	5	50
71 – 80	15	8	53
81 – 90	3	2	67
91 – 100	0	0	N/A

Six trees had bark beetle activity (*Dendroctonus spp.*), other than red turpentine beetle (*Dendroctonus valens*), at time of selection. Study tree mortality by year is displayed in Figure 2.

Figure 2. Study tree mortality by year.



The data collected allowed for a comparison of variables such as percent live crown and tree DBH between live and dead trees. These variables were analyzed using a standard t-test of means (Sokal and Rohlf 1987). Only sampled trees with at least 5 % crown scorch were used to calculate the means for live trees. Mean DBH and mean percent live crown were both significantly different between live and dead trees (Table 3).

Table 3. Mean Percent Live Crown and DBH Differences Between Live and Dead Trees

	Mean % Live Crown	Mean DBH
Live Trees n = 79	53.3 ± 18.1	19.0 ± 5.4
Dead Trees n = 21	38.0 ± 15.8	17.5 ± 2.5
p - value	<0.0004	<0.04

Discussion

The Crystal Fire presented an opportunity to monitor survivability of ponderosa and Jeffrey pines subjected to different degrees of fire injury. It also allowed an assessment of Wagener's marking guidelines for tree survival when trees had been injured following several years of below normal precipitation. It appears as though the pre-fire drought conditions factored little in tree survivability as the number of trees alive six years after the fire is much higher than expected based on Wagener's survivability marking criteria for live crown (50%). Of the 49 trees with less than 50% remaining live crown that were predicted to die, thirty two (65%) are still alive. Based on information obtained in this study we conclude that Wagener's guideline for tree survivability based on remaining live crown under estimates tree survival.

Since the initiation of this study we have experienced normal or above normal precipitation throughout northern California. The affect of higher than normal precipitation on this study is unknown and it is not possible to determine whether results obtained during a drier weather period would have been significantly different.

When trying to predict survivability of live trees following wildfire or prescribed burns it is important to remember that not all damage is identifiable with a visual inspection. Cambium damage, although not sampled in this study, is another criteria used for predicting tree survivability. Cambium damage is not equivalent to bark scorch (Weatherspoon 1988) and using bark scorch to assess cambium damage has not proved accurate in any situation (FHP evaluation reports). Thick duff layers surrounding boles can burn hot for extended periods causing extensive cambium damage without producing bark-scorching flames (Ryan and Frandsen 1991). In all cases, sampling must be done in order to accurately assess cambium damage if this criterion is being used in marking guidelines. Destructive sampling may be impractical for extensive use by marking crews, however, a cambium damage criteria should not be included in marking guidelines if individual tree sampling is not going to be conducted. Root damage is even more difficult to discern and definitely not practical for tree evaluation.

Percent crown scorch is the best predictor of tree mortality that is easily applied in the field. Studies of tree survival following burns in plantations have shown that percent crown scorch can be used to predict tree survival at a high rate of accuracy for trees with up to 60% crown scorch (Herman 1954) and in some cases up to 80% (Lynch 1959). Preliminary data from another FHP study on the 1999-2000 Divide Underburn, Volcano Plantation, Foresthill Ranger District, Tahoe NF, shows similar results. Data collected one year post-burn on mostly 6" to 16" DBH ponderosa pine shows an 89% survival rate for trees with crown scorch up to 60%, dropping to a 10 % survival rate for trees with crown scorch > 60%. Data from the Crystal Fire, six years post-burn, shows a survival rate of 91 % for trees with dead crowns up to 60%. The survival rate then drops to 55% for trees with > 60 % dead crown, which is still greater than one out of every two trees.

Accurately predicting survivability of fire-injured trees is essential when planning rehabilitation and salvage activities in burned areas particularly if the intent is to leave trees that are likely to survive. Currently Wagener's "Guidelines for estimating survivability of fire-damaged trees in California" is one of only a few documents that are available to land managers. The Crystal Fire study has added to this limited amount of information with site-specific data. Based on this data and data obtained from other FHP studies we have determined that Wagener's survivability guidelines for percent live crown should be adjusted from 50% to 35% (Appendix B). Therefore, excluding cambium damage, trees with >35% remaining live crown would be

expected to survive. It is also recommended that if the effort needed to sample cambium is impractical for salvage marking purposes than only percent green foliage or percent live crown should be used to predict survivability of fire damaged ponderosa and Jeffrey pine in eastside forest types.

If you have any questions regarding this report please contact us.

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Appendix A. Summary of Wagener's Guidelines for Ponderosa and Jeffrey Pine

Table A. General Specifications

Influencing Factors	Cambium Injury	% Live Crown	% Green Foliage
Fire period – late season Site quality – above average Growth vigor of tree before fire - good	None or light	≥ 50	≥ 10

Table B. Modifications (other general specifications unchanged)

Modified Influencing Factors	Cambium Injury	% Live Crown	% Green Foliage
In cambium injury – moderate	Moderate (≤25%)	≥ 50	≥ 20
In site – below average	None or light	≥ 50	≥ 15
In fire period – midseason	None or light	≥ 50	≥ 15 to 25
In growth vigor – crown small, vigor moderate	None or light	≥ 60	≥ 15

Appendix B. Recommended Modification of Wagener's Guidelines for Ponderosa and Jeffrey Pine

Table A. General Specifications

Influencing Factors	Cambium Injury	% Live Crown	% Green Foliage
Fire period – late season Site quality – above average Growth vigor of tree before fire - good	None or light	≥ 35	≥ 10

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